Missouri Department of Transportation

Bridge Division

Bridge Design Manual

Section 3.77

Revised 04/04/2005

[Click Here for Index](#)

Index

DESIGN UNIT STRESSES (also see Section 4 - Note A1.1)

(1) Reinforced Concrete

Class B Concrete (Substructure) fc = 1,200 psi f'c = 3,000 psi

Reinforcing Steel (Grade 60) fs = 24,000 psi fy = 60,000 psi

n = 10

$Ec = W^{1.5} \times 33\sqrt{f'c}$ (AASHTO Article 8.7.1) (✱)

(2) Structural Steel

Structural Carbon Steel (ASTM A709 Grade 36)

fs = 20,000 psi fy = 36,000 psi

(3) Piling

For pile capacity, see Bridge Manual Sec. 1.4 and 3.74. Also, see the Design Layout if pile capacity is indicated.

(4) Overstress

The allowable overstresses as specified in AASHTO Article 3.22 shall be used where applicable for Service Loads design method.

(✱) $E_C = 57{,}000\sqrt{f'c}$ for W = 145 pcf, $E_C = 60{,}625\sqrt{f'c}$ for W = 150 pcf

LOADS

(1) Dead Loads

As specified in Bridge Manual Section 1.2.

(2) Live Load

As specified on the Design Layout.
Impact of 30% is to be used for design of the beam. No impact is to be used for design of any other portion of bent including the piles.

(3) Temperature, Wind and Frictional Loads

See Bridge Manual Section 1.2.4.

DISTRIBUTION OF LOADS

(1) Dead Loads

Loads from stringers, girders, etc. shall be concentrated loads applied at the intersection of centerline of stringer and centerline of bearing. Loads from concrete slab spans shall be applied as uniformly, distributed loads along the centerline of bearing.

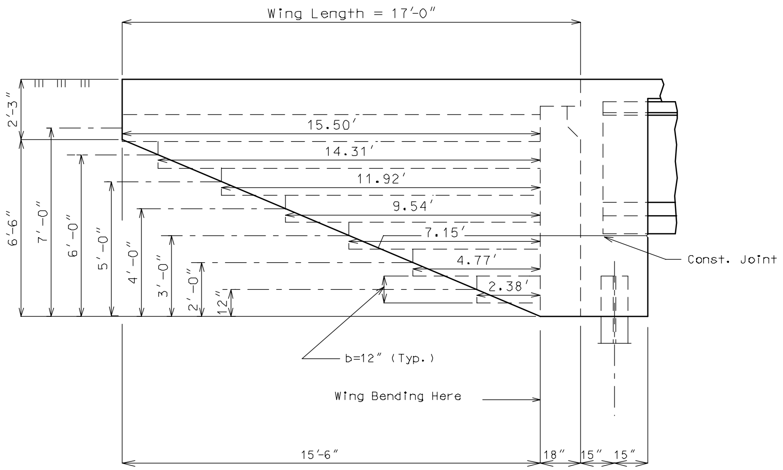
(2) Live Load

Loads from stringers, girders, etc. shall be applied as concentrated loads at the intersection of centerline of stringer and centerline of bearing. For concrete slab spans distribute two wheel lines over 10'-0" (normal to centerline of roadway) of substructure beam. This distribution shall be positioned on the beam on the same basis as used for wheel lines in Traffic Lanes for Substructure Design (See Section 1.2).

(3) Wing with Detached Wing Wall

When wing length, L, is greater than 17'-0", use maximum length of 10'-0" rectangular wing wall combined with a detached wing wall, see page 1.1-2 of this section. When detached wing walls are used, no portion of the bridge live load shall be assumed distributed to the detached wing walls. Design detached wing wall as a retaining wall, see Sec.3.62 for retaining wall design. (The weight of Safety Barrier Curb on top of the wall shall be included in Dead Load.)

EXAMPLE 1: Design horizontal reinforcement of the following wing with wing length of 17'-0". Use 90 psf for live load surcharge and 45 psf/linear foot for earth pressure (Use load factor design).



SOLVE:

Factored Soil Pressure = 1.3γ x45 psf/ft = 1.3x1.3x45 psf/ft = 76.05 psf/ft.
Factored Surcharge = 1.3 γ x90 psf = 152.1 psf. (AASHTO 5.14.1, 5.14.2)

Find the bending moment of wing about edge of brace due to earth pressure and live load surcharge:

1st foot from bottom of wing (h=7.75'):

EP = Earth Pressure = Soil Pressure + Surcharge
EP = 7.75'x76.05 psf/ft + 152.1 psf = 741.5 psf
M = Moment = 741.5 psf x (2.38'x1') x 2.38'/2 = 2100 ft.-lb.

2nd foot from bottom of wing (h=6.75'):

EP = 6.75'x76.05 psf/ft + 152.1psf = 665.4 psf
M = 665.4 pst x (4.77'x1') x 4.77'/2 = 7570 ft.-lb.

3rd foot from bottom of wing (h=5.75'):

EP = 5.75' x 76.05 psf/ft + 152.1 psf = 589.4 psf
M = 589.4 psf x (7.157'x1') x 7.157'/2 = 15,065 ft.-lb.

4th foot from bottom of wing (h=4.75'):

EP = 4.75' x 76.05 psf/ft + 152.1 psf = 513.3 psf
M = 513.3 psf x (9.54'x1') x 9.45'/2 = 23,358 ft.-lb.

5th foot from bottom of wing (h=3.75'):

EP = 3.75' x 76.05 psf/ft + 152.1 psf = 437.3 psf
M = 437.3 psf x (11.92'x1') x 11.92'/2 = 31,067 ft-lb.

6th foot from bottom of wing (h = 2.75'):

EP = 2.75' x 76.05 psf/ft + 152.1 psf = 361.2 psf
M = 361.2 psf x(14.31'x1')x14.31'/2 = 36,983 ft-lb. ← Control

7th foot from bottom of wing (h=1.75'):

EP = 1.75' x 76.05 psf/ft + 152.1 pst = 285.2 psf
M = 285.2 psf x (15.5'x1') x 15.5'/2 = 34,260 ft.-lb.

DESIGN EXAMPLE (CONT.)

Design

Example 1 (Cont.)

Mu=36,983 ft-lb, f'c=3000 psi, fy=60 ksi, assume #6 vertical bar and #6 horizontal bar.

Wing wall thickness = 16"

Effective d = 16"-2"Clear(exposed to earth)- 0.75"(vert. bar)- 0.375"(horiz. bar)
= 12.875"

b = 12", Ø = 0.9

$$As = \frac{0.85\ f'c\ b\ d}{fy}\left[1-\sqrt{1-\frac{2\ Mu\ (12''/ft.)}{0.85\ f'c\ Ø\ b\ d^2}}\right]$$

$$= \frac{(0.85)(3)(12'')(12.875'')}{60}\left[1-\sqrt{1-\frac{(2)(36{,}983)(12)}{(0.85)(3000)(0.9)(12)(12.875)^2}}\right]$$

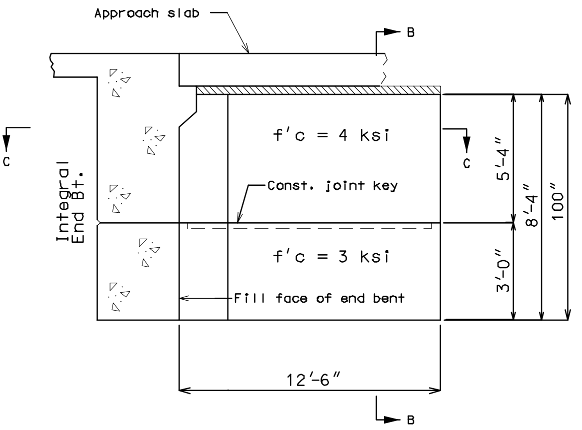
$$= 0.673 \text{ sq. in.}$$

Use #6 @ 8" cts. (As = 0.663 sq. in.)

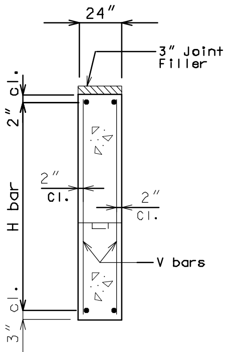
Use #6 @ 8" cts. Horizontal Bars and use #6 @ 8" cts. Wing Brace Reinforcing Bars

DESIGN EXAMPLE
Example 2

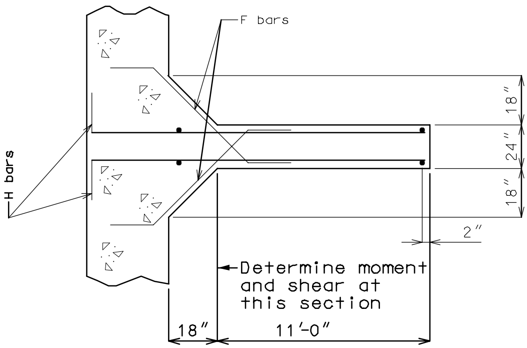
Design H-bar and F-bar of an intermediate wing as shown in the figures below (wing length = 12.5′, wing thickness = 24″, wing height = 8′-4″), a Seismic Force of ω = 12.21 kips/ft. is applied on the wall.



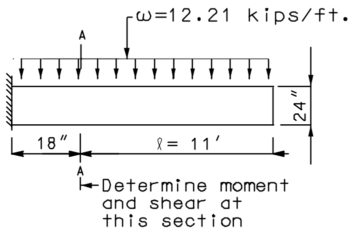
SECTION NEAR INTERMEDIATE WING



SECTION B-B



SECTION C-C



Interior Wing Design

Solve: Assume #6 V bar, #8 H bar, #6 F bar

1/ <u>Design H-bar for bending</u>

d = 24″-2″(clr.)-0.75″(V bar)-0.5x1″(H bar) = 20.75″,
ℓ = 11′, ω = 12.21 kips/ft., b = 8′-4″ = 100″

At section A-A:
$Mu = (1.0)(\omega\ell^2/2) = 12.21 \times 11^2/2 = 738.705$ kips-ft.

$Ru = Mu/(\emptyset\, bd^2) = 738.705\times12{,}000/(0.9\times100''\times(20.75'')^2) = 228.85$ psi

use f′c = 3 ksi, fy = 60 ksi

$m = fy/(0.85\ f'c) = 60/(0.85\times3) = 23.53$

$\rho = (1/m)\left[1-\sqrt{1-2Rum/fy}\right] = (1-\sqrt{1-2\times228.85\times23.53/60000})/23.53 = 0.004003$

As (Req′d) = ρ bd = 0.004003x100″x20.75″ = 8.31 sq. in.

Try #8 @ 9″, USE $\dfrac{100''-3''(clr.)-2''(clr.)-1''(\#8\ bar)}{9''}$ = 10.44 spacing

Say 11 spacings, 12 bars(Each Face)

Total Area = 12 (0.7854) = 9.42 sq. in.> 8.31 sq. in., USE 12-#8 H-bar (each face)

DESIGN EXAMPLE(CONT.)
Example 2 (Cont.)

2/ Design F-bar for shear

$Vu \le \varnothing(Vc + Vs)$, $\varnothing = 0.85$ (AASHTO Article 8.16.6.1.1)

At Section A-A:
$Vu = 1.0\times(\omega\ell) = (12.21 \text{ kips/ft.})(11') = 134.11$ kips

$Vc = bd(\upsilon c) = bd(2\sqrt{f'c}\,) = (100''\times20.75'')(2\times\sqrt{3000})/1000 = 227.30$ kips

$\varnothing Vc = 0.85Vc = 0.85\times227.30$ kips $= 193.20$ kips

$\varnothing Vc = 193.20$ kips $> Vu = 134.11$ kips, No Vs needed by AASHTO Article 8.16.6.3.1.

$0.5(\varnothing Vc) = 0.5\times193.20 = 96.60$ kips $< Vu = 134.11$ kips.

Minimum shear reinforcement is required by AASHTO Article 8.19.1.1(a).
(ACI 318-95 11.5.5.1)

F-bar is a single group of parallel bars, all bent up at the same distance from support (no "spacing" along the "L" direction of the wing).

Try #6 @ 12" F-bar (each face).

Try (100"-3"-2"-1")/12" = 7.83, say 8 spacing, 9 bars (each face).

Since seismic force is a cyclic loading, assume one bar works at any instance.

Av(provided) = 1x9x(0.4418 sq.in.) = 3.98 sq. in.

$Vs = Av(Fy \sin 45°) = (3.98 \text{ sq. in.})(60 \text{ ksi})(\sin 45°) = 168.7$ kips.

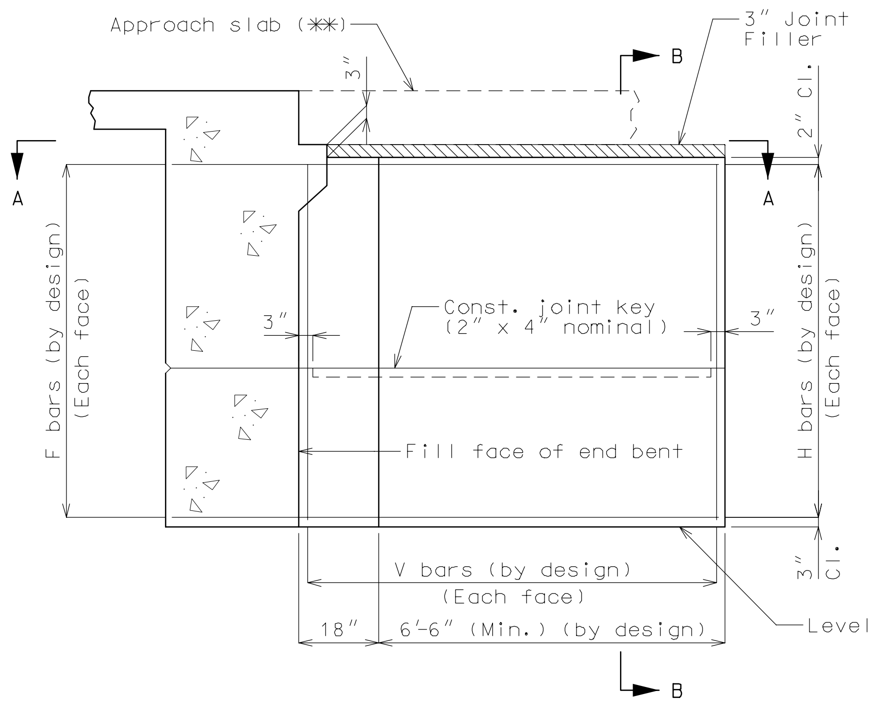
Check $3\sqrt{f'c}\, b_\omega d = 3\sqrt{3000}\times100''\times20.75''/1000 = 341.0$ kips.

$Vs = Av(Fy \sin 45°) \le 3\sqrt{f'c}\, b_\omega d$, O.K. by AASHTO Article 8.16.6.3.4.

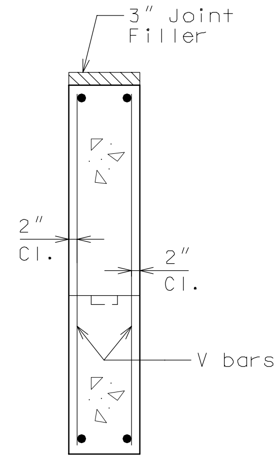
USE 9 #6 F-bars (each face).

EARTHQUAKE LOADS AT END BENTS INTERMEDIATE WING (SEISMIC SHEAR WALL)

Reinforcement



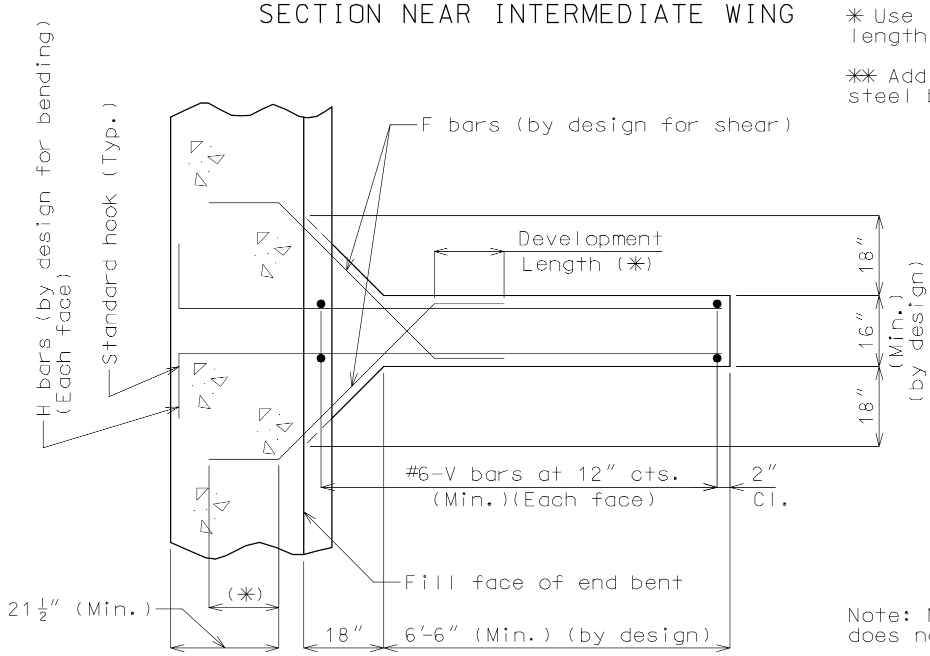
SECTION NEAR INTERMEDIATE WING



SECTION B-B

✱ Use 1.25 x development length for seismic design.

✱✱ Additional reinforcing steel by design if required.



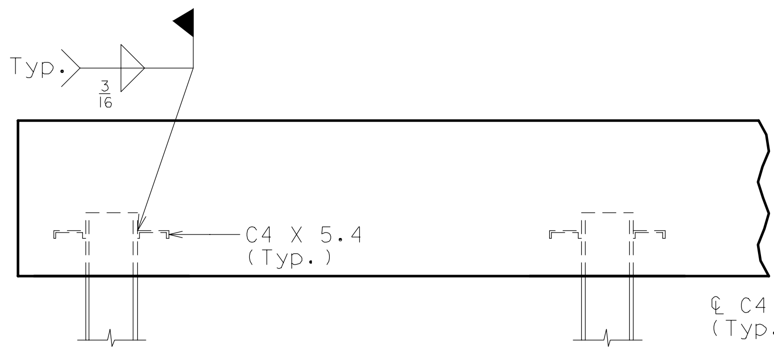
Note: Make sure reinforcement does not interfere with girders.

SECTION A-A

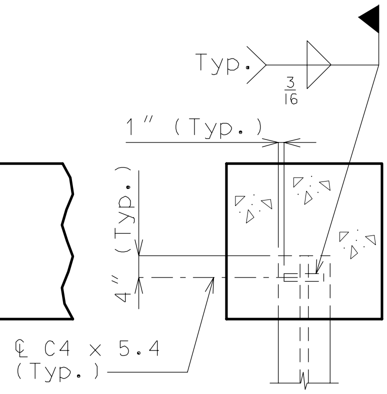
Reinforcement

ANCHORAGE OF PILES FOR SEISMIC PERFORMANCE CATEGORIES B, C & D.

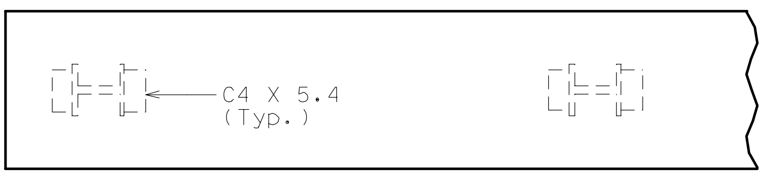
STEEL PILE



PART ELEVATION OF BEAM



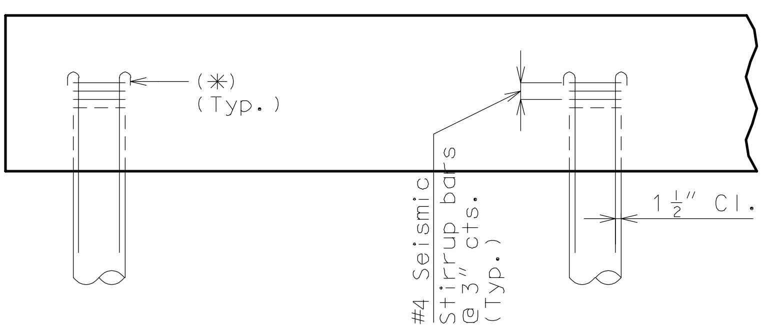
SECTION THRU BEAM



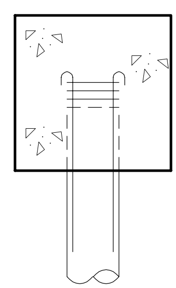
PART PLAN OF BEAM

Note: Channel shear connectors are to be used for all steel piles in end bent.

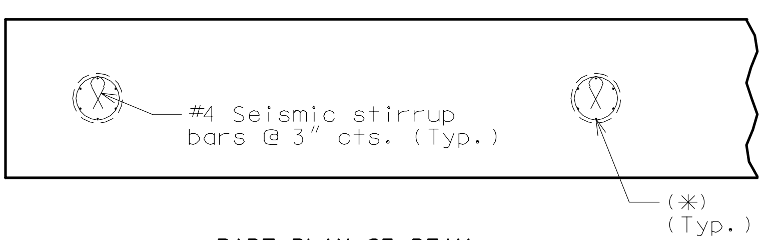
CAST-IN-PLACE PILE



PART ELEVATION OF BEAM



SECTION THRU BEAM



PART PLAN OF BEAM

(✳) See Bridge Manual Section 3.74 (Piling) for anchorage reinforcement required.

CONCRETE PILES (CAST-IN-PLACES)

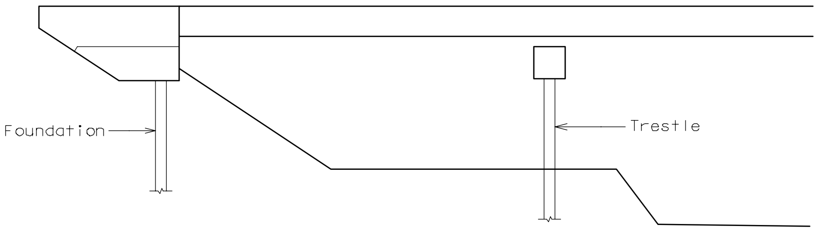
Details

The details of cast-in-place piles will be as indicated on Missouri Standard Plans (English Version) Std. Drawing 702.02., except that the shell and location type must be indicated on the Plans as specified on the Design Layout.

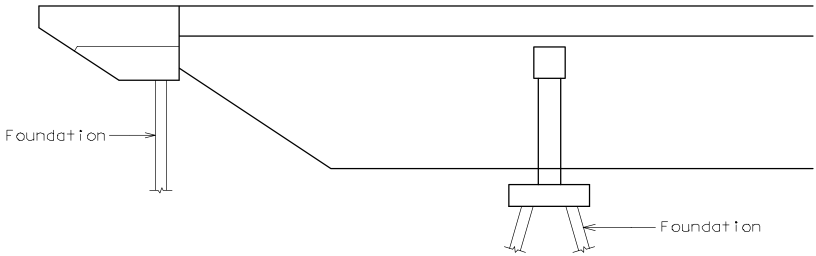
The KIND and TYPE of CIP pile shall be indicated in the "PILE DATA" table on Design Plans.

The TYPE of pile, trestle or foundation, may be selected from the illustrations shown below. When the illustrations indicate that there would be both trestle and foundation piles on the same structure, use all piles as trestle piles throughout the structure, regardless of the type of bent.

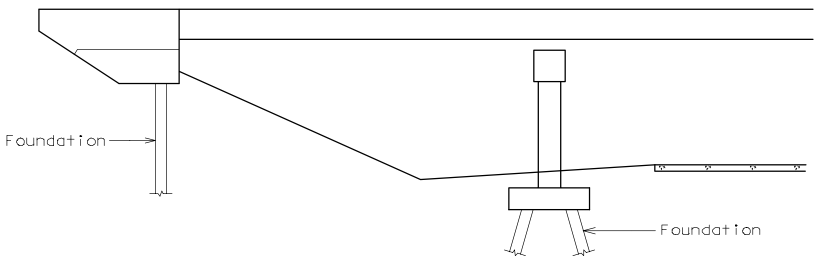
The shell, thick or thin, will not be indicated in the "PILE DATA" table, unless specified on the Design Layout.



STREAM CROSSING

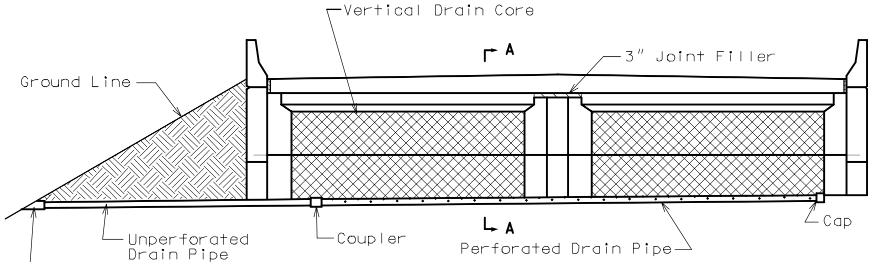


STREAM CROSSING



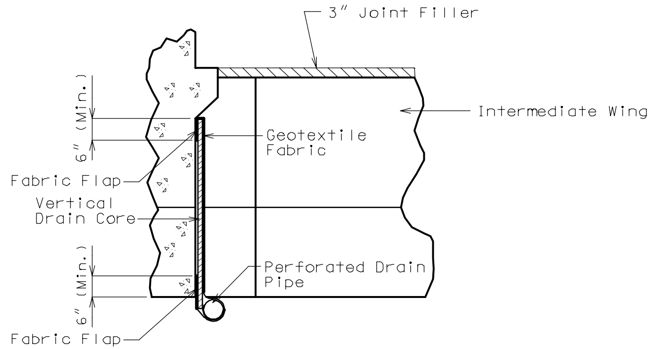
GRADE SEPARATION

VERTICAL DRAIN AT INTEGRAL END BENTS (CONT.) (WITH INTERMEDIATE WING)



ELEVATION AT END BENT
(with intermediate wing)

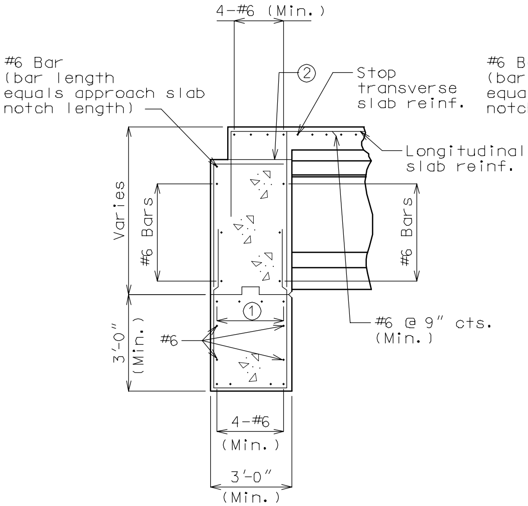
NOTE: See Bridge Manual Section 4 for appropriate notes.



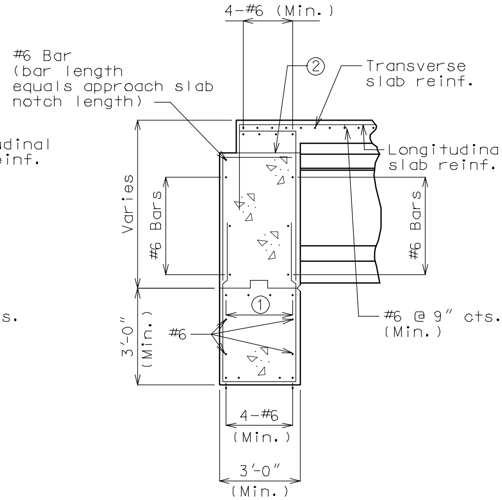
PART SECTION A-A

SQUARE WING/SQUARE APPROACH SLAB NOTCH
Reinforcement

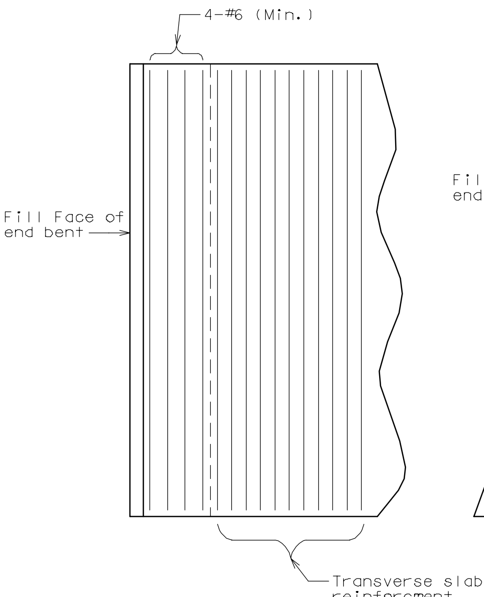
WIDE FLANGES, PLATE GIRDERS & PRESTRESSED GIRDERS



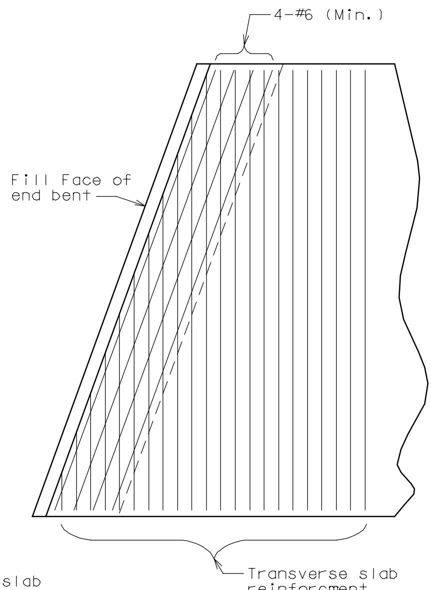
SECTION THRU
SQUARE END BENT



SECTION THRU
SKEWED END BENT



PLAN
SQUARE END BENT



PLAN
SKEWED END BENT

Note: Sections shown above are between girders and piles.
Prestressed I girders are shown in the sections above; Steel girders are similar.

① Use same as bottom reinforcement.

② Use construction joint on steel structures only.